The Amazing Compact Hydroponic Farm

by Bob Stevenson

George Stevenson, age 86, stands next to some of the organic strawberry crop growing in his Compact Hydroponic Farm. He found this remarkable plant-growing unit very easy and inexpensive to operate. The Compact Hydroponic Farm can solve not only the pressing food needs of the elderly, but of those living on a limited income.

Imagine just 20 square feet of space—the size of a small patio—becoming your own organic farm, and not just merely a garden. It would best be called a **farm** because thanks to your use of a uniquely-designed hydroponic unit, you would be easily and inexpensively producing so many organic vegetables, herbs and even certain fruit (such as strawberries) that you would have to frequently give away much of your crop because you couldn't eat it all yourself. Seems impossible? Well, it's not. In fact, for many people it was a reality. With prices for fresh organic produce increasingly becoming unaffordable, it is important to find another way to meet one's food needs. And now you are about to learn more about the amazing Compact Hydroponic Farm and how it was able to greatly help people meet their fresh organic food needs.

Summarized Technical Description of the Compact Hydroponic Farm

The Compact Hydroponic Farm is a versatile apparatus, as it can be utilized in home, commercial and industrial settings. The apparatus is basically composed of a series of horizontally positioned plastic PVC pipes or ducts which support a plurality of plants maintained in individual foundational or planting cups, the latter of which generally number 98. The planting cup is preferably a standard-sized 6-ounce Styrofoam cup or is composed of a similar material which can be easily cut. The lower surface of the planting cup extends partially into the duct and contains a series of slot-like cuts 1/32 inch in width and about ½ inch in height to permit the roots of the plant to extend within the duct yet maintain the sterile media in a substantially isolated condition from the direct flow of the nutrient liquid. The sterile media used is plain construction sand.

The organic (kelp based) or regular hydroponic fertilizer nutrient solution is initially supplied to the ducts by a pump and thereafter travels under gravity flow through the ducts in a series path. The nutrient solution is maintained at dual levels during operation of the Compact Hydroponic Farm, thereby ensuring that proper amounts of water and nutrients are provided to the plants. At the first level, the nutrient liquid slightly contacts or wets the lower surface of the planting cup thereby allowing capillary action to draw the liquid into the sterile media to nourish young plants or seedlings. At a second level, the nutrient liquid is only present in the lower portion of each duct to continuously feed the root system of the more mature plants. As such, the media does not filter the nutrient liquid and thus does not become contaminated after prolonged use.

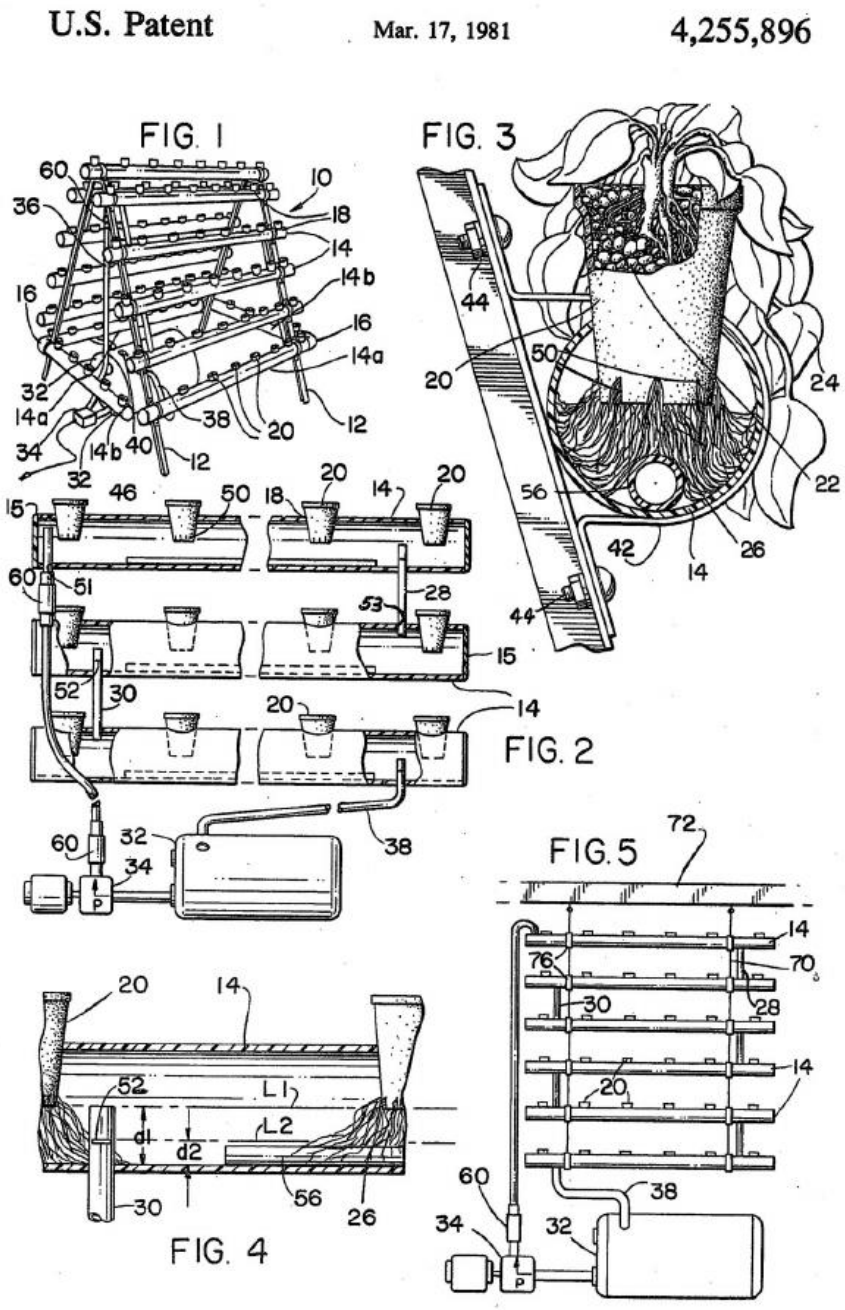
In addition, the operation of the Compact Hydroponic Farm facilitates easy removal of individual plants from the apparatus by simply removing the plant cup from the duct. Due to the upper root structure of the plants and sterile support media being isolated within the plant cup, the

planting cup, media and plant may be readily lifted from the Compact Hydroponic Farm as an integral unit, without disturbing the plant within the media or tearing the root system. Further, by this same procedure, individual plants may be readily relocated upon the apparatus to facilitate more direct exposure to the incident sunlight or shade.

Additionally, the individual plant cups form a substantially air-tight seal with the ducts which, in combination with the closed flow communication between individual ducts, provides a substantially hermetically-sealed hydroponic growing apparatus. As such, the evaporation and rain flooding deficiencies associated with other hydroponic apparatuses are substantially eliminated, as well as the attendant elimination of the greenhouse hydroponic environments.

Further, due to the sterile media (i.e., the plain construction sand) being maintained within the planting cup, and substantially isolated from the direct nutrient flow, scheduled clean-out of the Compact Hydroponic Farm is significantly reduced, typically being necessitated only once every 5 to 6 months. In this same regard, the Compact Hydroponic Farm provides a quick disconnect supply conduit which facilitates complete clean-out of the apparatus with a garden hose in a matter of minutes. Finally, the plural ducts of the apparatus are arranged in a vertically stacked arrangement which supports a maximum number of plants in a minimum surface area (about 20 square feet). Thus, prodigious plant yield can be obtained without one even needing to possess a backyard; a small patio space suffices to allow one to benefit from the Compact Hydroponic Farm.

The planting cup is seen removed from its nearby duct. The lettuce plant's roots extend below the cup through slits cut into the bottom part of the cup.



Technical drawings of the Compact Hydroponic Farm and its key constituent parts

DESCRIPTION OF THE DRAWINGS

The multiple advantages and benefits of the Compact Hydroponic Farm, as well as its advanced design, will become more apparent upon reference to the following drawings contained in the apparatus's U.S. Patent.

FIG. 1 is a perspective view of the Compact Hydroponic Farm showing the vertical stacked arrangement of ducts upon a support frame with the individual planting cups mounted on each duct.

FIG. 2 is an enlarged partial cross-sectional view of three of the ducts of the Compact Hydroponic Farm showing the relationship between the planting cups, inlet tube, outlet tube, bypass tube, electric light duty water pump (200-300 gallons per hour) and 30-gallon water tank.

FIG. 3 is an enlarged cross-sectional view of one of the ducts of the Compact Hydroponic Farm showing its mounting to the support frame and the orientation of the planting cup and root system of the plant within the duct.

FIG. 4 is a partial longitudinal sectional view of one of the ducts of the Compact Hydroponic Farm depicting the dual nutrient flow level of the apparatus.

FIG. 5 is an elevational view of an alternative embodiment of the Compact Hydroponic Farm with the ducts arranged in a vertical ladder-like configuration.

The Compact Hydroponic Farm was available in kit form for several years beginning in the late 1970s. My grandfather, George Stevenson, purchased one in 1979 and assembled it in his back yard. It produced so much organic produce, especially tomatoes and squash, that he was constantly giving away a lot of his crop to neighbors and relatives. He was even able to grow large numbers of strawberries in the unit (see title page photo). I was naturally one of the lucky recipients of some of George's Compact Hydroponic Farm crop, for all the organic produce was as tasty and delicious as one could want. George had a timer on his unit's pump, and the timer's setting made the water and its nutrient solution circulate through the ducts frequently, although not continually, during the day. At night George turned off the pump, and even with the pump turned off there remained enough water and nutrient solution in each duct to immerse the roots of each plant. In short, operation of the Compact Hydroponic Farm was essentially automatic.

The multiple advanced design features of the Compact Hydroponic Farm (CHF) are easily seen here. The 13 ducts (white pipes), whose internal diameters measure 3 inches, are attached to six metal support rods, creating an A-frame shaped compact hydroponic growing system. The green 30-gallon water tank is centrally positioned at the base of the CHF. An electric light duty 1.0 – 1.5 AMP outdoor fountain water pump (200-300 gallons per hour) connected on one of its ends via a flexible short tube (hose) to the water tank and on its other end to a long green hose delivers nutrient solution to the top duct. The nutrient solution then travels to the opposite end of the duct where it exits the duct via an outlet tube and enters the duct positioned below it. Utilizing the force of gravity, the nutrient solution continues its series flow path through the CHF until it returns to the water tank. The eight planting cups on each duct are spaced approximately 8 inches apart from each other, allowing plenty of air and light around each plant, maximizing plant growth in the process. Even in cups that contain small, young plants one sees that very little surface area of the support sand is exposed to the air, meaning that not much rain on a rainy day would penetrate into each duct and dilute the nutrient solution. One also sees that it's wise to locate a larger plant on one of the four lowest level ducts in order to: 1) not shade other plants and 2) allow the plant's vine, if it were a melon or squash, for example, to travel a distance along the ground.

SUMMARY OF THE FEATURES, ADVANTAGES AND BEST WAY TO OPERATE THE COMPACT HYDROPONIC FARM

EVAPORATION

Evaporation of nutrient solution is a major problem with traditional hydroponic systems due to their wide, exposed growing media area. This problem does not exist with the Compact Hydroponic Farm because the amount of the plain construction sand used in the apparatus is so small that evaporation is minimized. Further, nutrient solution is always present inside each duct, even with the pump turned off, and never becomes stagnant thanks to the pump's frequent operation during the day. Finally, with the planting cups being self-sealing, the entire apparatus itself is essentially sealed, making it impossible for any significant amount of nutrient solution to evaporate.

NUTRIENT BUILDUP

Buildup and uncontrolled release of different elements by growing media is another major problem with traditional hydroponic systems. However, this is not the case with the Compact Hydroponic Farm, as its design does not filter the nutrient through supporting media; instead, the nutrient solution simply flows over the exposed plant roots. As mentioned earlier, plain construction sand is used in the planting cup to provide support for the plant stem, but it remains inside the planting cup and does not enter the duct. This yields the additional benefit of the Compact Hydroponic Farm not experiencing any problem with pH buildup and the need for constant pH control.

CONTAMINATION

Thanks to the advanced design of the Compact Hydroponic Farm, removing a plant does not leave broken roots behind in a media. When one takes out a planting cup that contains a growing plant, the plant's root also comes out. Thus, the plant's media (plain construction sand) is not

contaminated. Also, the nutrient solution cannot be contaminated because the nutrient solution does not flow through or flood the planting cup's supporting sand. This therefore prevents any foreign organics or chemicals from ever reaching the nutrient solution. Just as importantly, each plant in the Compact Hydroponic Farm has an exposed area of sand around it of only 2½ inches in diameter. Therefore, the leaves of the plant will usually effectively shield any exposed sand from most raindrops should there be rain, thereby eliminating the need to throw out diluted nutrient.

DRAIN HOLES

Connecting each duct (pipe) to the one below is a ¾-inch flexible reinforced vinyl tube (as commonly used in garden hoses). The top end of the connecting tube therefore serves as a drain hole for the top duct. However, this drain hole can become restricted by roots from large rooting plants. To prevent this drainage restriction, simply locate plants which produce large roots to the opposite end of the duct, far away from the drain hole. Meanwhile, due to the advanced, hermetically-sealed design of the Compact Hydroponic Farm, it is impossible for leaves or other foreign material to enter the apparatus from the outside and clog up any drain holes. So, the main thing respecting drain holes one needs to pay attention to is the size and location of plants with large roots. In general, should a plant's root seem to have grown too large and long, the plant and its support cup can be lifted out of its hole and some of its root can be trimmed without affecting the continued growth of the plant.

PUMPS AND TIMERS

Thanks to the Compact Hydroponic Farm being a hermetically-sealed apparatus, a pump or timer failure does not create a critical problem. This is because all of the apparatus's ducts will retain some nutrient solution in them when the pump is idle. Also, because there is basically no airflow in the ducts, the humidity level inside them is high. This high humidity level results in the plants being able to last for several days before they show any signs of a need to receive any more nutrient solution.

LIGHT AND AIRFLOW

Because of its advanced terraced tubular design, the Compact Hydroponic Farm permits one to grow many more plants per square foot of ground space than other hydroponic systems which are based on a large, flat, open area of growing media. As a bonus, it provides a surprisingly large amount of open space between the plants, which allows for a great deal of airflow and light around them, resulting in a very positive growing condition for the plants.

PROTECTION AGAINST SMALL ANIMALS AND INSECTS

The Compact Hydroponic Farm is well off the ground and all four of its legs combined contact the ground on less than one square inch. This renders the apparatus essentially small animal proof. Also, snails, slugs or other crawling insects are very unlikely to find one of the legs to climb up. However, should that prove to be a problem, one can deposit some deterring liquid or powder around the base of each leg.

CLEANING THE COMPACT HYDROPONIC FARM

To clean the Compact Hydroponic Farm you: 1) first remove a planting cup from the top duct; 2) insert a garden hose into this opening; 3) turn the hose on to full strength; 4) the water from the hose will clean all the ducts and wash nutrient into the water tank; 5) at the same time disconnect the hose used to carry nutrient solution from the water tank to the top duct (a quick disconnect is provided for this purpose); 6) turn on the pump, and this will cause the solution to be pumped out onto the ground; 7) allow the pump to run until the water that's being pumped out of the water tank runs clear (this may take 20-30 minutes); 8) turn off the garden hose; 9) replace the planting cup and reconnect the water tank pump; 10) add fresh nutrient to the water tank. This cleaning process needs to be done only twice per year.

PLANT LOCATION

One can remove a plant in its planting cup from its cup hole and move it to another cup hole with no problem whatsoever. One might wish to do this to small plants that are shaded by larger older plants. One can also start a plant in its planting cup before placing it in the Compact Hydroponic Farm. By doing this, one can have replacements for older plants ready at all times to be installed in the apparatus. Flowers, of course, can be grown in the Compact Hydroponic Farm, too. Once the flowers are large enough, one can place the planting cup in which the flowers have been growing into a vase. It is recommended that the planting cup containing the flowers be returned after 3 or 4 days to the Compact Hydroponic Farm. Another living bouquet arrangement could then be brought into the house if one had started growing flowers in another planting cup. Fruit-bearing plants (strawberries, blackberries, melon, etc.) often produce more fruit if their roots are pruned. One cannot see the extent of the root system of a plant that's growing in the ground, thus making it easy for one to prune too much or too little of the plant's roots. However, because one can see the length and size of the roots of a plant grown in the Compact Hydroponic Farm, one will readily learn how much of the roots of a strawberry plant, for example, that's been growing in the apparatus one should cut in order to maximize growth of the plant.

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THE ULTIMATE COMPACT HYDROPONIC FARM

Completely Plastic-free and Made with Ceramic

We have seen how almost all of the parts of the Compact Hydroponic Farm are made of plastic-based materials. Even the Styrofoam planting cups are composed of plastic, as Styrofoam is made of expanded polystyrene, which is a form of plastic. When the original Compact Hydroponic Farm design was patented in 1981, Science had not determined that consuming microplastic particles from one's food and drinks (water, etc.) would significantly harm human health. That level of unawareness is no longer the case. Scientific studies have found that when food and liquid come into contact with plastic items (such as plastic water bottles or plastic food containers),

microplastic or nanoplastic particles may enter into the food or liquid. Microplastics (MPs) are particles smaller than 5 millimeters (mm) in size while Nanoplastics (NPs) are tinier particles, ranging from 1 nanometer to 1000 nanometers in size. Unfortunately, especially given the pervasiveness of the use of plastic in the world today, scientific studies published in such highly-regarded, peer-reviewed journals as *Journal of the American Medical Association (JAMA), Environmental Science & Technology Letters, Nature Medicine, Science Advances*, and *eBioMedicine* have proven that MPs and NPs cause numerous harms to the human body. For example, MPs were found to become trapped within the narrow capillaries of the brain, causing various neurological problems, such as dementia, depression, anxiety, impaired balance and endurance, as well as slower bodily movement. But, it's extremely important to understand how serious a problem plastic consumption has become for the health of children and others. So, here is a lengthier list of the damage that consumption of MPs and NPs causes to human health, as determined by scientific studies published in the above-listed journals:

Promotes Parkinson's disease-associated alpha-synuclein aggregation
Up-regulation of pro-inflammatory cytokines
Affects gene transcription
Reduces cell viability
Decreases transepithelial electrical resistance
Affects atrioventricular heart valve development
Decreases thrombin formation
Damages cell membranes
Induces autophagy and autophagasome formation
Dysregulates protein related to cancer signaling
Mitochondrial damage in cells
Gut microbiota dysbiosis
Lipid metabolism disturbances
Increases oxidative stress in cells

Clearly, all the parts of the Compact Hydroponic Farm need to be composed of a durable, non-plastic material. And, the ideal material for this would be ceramic, which happens to be an even better choice of material than glass. Some of the many advantages of ceramic include: 1) its high

compressive strength, meaning it can withstand significant pressure without breaking; 2) it is extremely hard and resistant to scratches and wear; 3) has high thermal resistance and excellent resistance to chemical erosion; 4) has a higher tensile and compressive strength than glass and is also less brittle than glass.

Given the many positive attributes of ceramic which would make it the ideal material for the Compact Hydroponic Farm (CHF) to be composed of, it's simply a matter of making the CHF out of ceramic. And, in fact, this can be done by utilizing the 3D-printing manufacturing process. It turns out that ceramic can be and has been 3D printed. The ceramic used to make the CHF would need to be solid colored—not clear like glass. This is because plant roots grow better in darkness, as they exhibit negative phototropism, meaning they avoid light; light exposure can induce a stress response that affects their growth and development. So, it would be wise to make the 13 ducts of the Compact Hydroponic Farm into which the 98 planting cups are placed out of a solid white-colored ceramic (the white being an easier background color for one to examine the plant). An excellent 3D-printed design of the CHF would minimize the number of parts that need to be assembled. The 98 ceramic planting cups would be 3D-printed separately and would have to be placed individually into the duct holes by the unit's operator. However, the ¾-inch connecting tubes as well as the CHF's support frame could be 3D-printed all together along with the ducts. While making assembly of the rest of the CHF (i.e., the ceramic water tank, the pump, and the ceramic tubes connecting the pump to the water tank and also to the top duct) quite easy, shipping a nearly completely-assembled 3D-printed CHF would be a challenge, due to its size and weight. So, most likely a ceramic-based CHF would end up being offered in kit form, just as was the case with the original Compact Hydroponic Farm. Fortunately, the original 1981 patent for the CHF expired in 1999; so, marketing a ceramic-based CHF can be done without infringing on any patent.

In looking at the promise of the Compact Hydroponic Farm, society must ask itself: "Are we truly serious about providing inexpensively-grown fresh, organic food—food uncontaminated by plastic or other toxins, such as pesticides and herbicides—to our children and others?" If the answer is "Yes," then development, mass production and widespread use of the plastic-free, 3D-printed ceramic Compact Hydroponic Farm must be prioritized. In the meantime, do your part to see to it that society values production of inexpensive fresh, organic fruit and vegetables and the ways which make this possible.